518 Rec'd PCT/PTO 02 AUG 2001

FORM PTO-1390 (REV 10-97) U.S. Department of Commerce Patent and Trademark Office

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER: CR1028AC

U.S. APPLICATION NO.: 09/890618

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/IB00/00102	02 FEBRUARY 2000	09 FEBRUARY 1999

TITLE OF INVENTION:

A METHOD OF PROVIDING AN EXTENSION TO A SIGNAL AND APPARATUS THEREFOR

APPLICANT(S) FOR DO/EO/US
KHARITONENKO

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [X] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. [ ] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. [X] This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the application time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. [ ] A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. [X] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [ ] are transmitted herewith (required only if not transmitted by the International Bureau).
   b. [X] has been transmitted by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US).
6. [ ] A translation of the International Application into English (35 U.S.C. 371 (c)(2)).
7. [X] Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3)).
   a. [X] are transmitted herewith (required only if not transmitted by the International Bureau).
   b. [ ] has been transmitted by the International Bureau.
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [ ] have not been made and will not be made.
8. [ ] A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. [X] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. [ ] A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 16 below concern other document(s) or information included:

11. [X] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [ ] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [ ] A FIRST preliminary amendment.
    [ ] A SECOND or SUBSEQUENT preliminary amendment.
14. [ ] A substitute specification.
15. [ ] A change of power of attorney and/or address letter.
16 [ ] Other items or information:

JC17 Rec'd PCT/PTO 02 AUG 2001

U.S. Application No. (if known, see 37 CFR1.5)	International Application No.	Attorney Docket Number
09/890618	PCT/IB00/00102	CR1028AC

				CALCULATIONS	PTO USE ONLY
17. [X] The following fees are submitted: **Basic National Fee (37 CFR 1.492(a)(1)-(5):** Search report has been prepared by the EPO or JPO ....$930.00 International preliminary examination fee paid to USPTO (37 CFR 1.482) ....$720.00 No International preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445 (a)(2))....................$710.00 Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO......................$1,000.00 Intentional preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) $100.00					
ENTER APPROPRIATE BASIC FEE AMOUNT =				$ 930.00	
Surcharge of $130.00 for furnishing the oath and declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)). +				$	
Claims	Number Filed	Number Extra	Rate		
Total Claims	65 - 20 =	45	X $18.00	$ 810.00	
Independent Claims	7 - 3 =	4	X $80.00	320.00	
Multiple dependent claim(s) (if applicable)			+$270.00	$	
TOTAL OF ABOVE CALCULATIONS =				$ 2060.00	
Reduction by 1/2 for filing by small entity, if applicable. Verified Small Entity statement must also be filed. (Note 37 CFR 1.9, 1.27, 1.28).				$	
SUBTOTAL:				$ 2060.00	
Processing fee of $130.00 for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$	
TOTAL NATIONAL FEE =				$ 2060.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property +				$	
TOTAL FEES ENCLOSED =				$ 2060.00	
				Amount to be refunded	$
				charged	$ 2060.00

a. ☐ A check in the amount of $____________ to cover the above fees is enclosed.

b. [X] Please charge my Deposit Account No. 13-4772 in the amount of $ 2060.00 to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [X] The Commissioner is hereby authorized to charge any additional fees which may be required now or in the future under 37 CFR 1.16 or 37 CFR 1.17, including any present or future time extension fees which may be required, or credit any overpayment to Deposit Account No. 13-4772 . Two duplicate copy of this sheet is enclosed.

Note: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.

Send all correspondence to:

Motorola, Inc.
Intellectual Property Department, 3rd Floor
1303 E. Algonquin Road
Schaumburg, Illinois 60196

DANIEL K. NICHOLS
Attorney for Applicant(s)
Reg. No.: 29,420
Telephone: (847) 576-6364
Fax No.: (847) 576-3750

A Method of Providing an Extension to a Signal and Apparatus Therefor

Field of the Invention

This invention relates to a method of providing an extension to a signal and to apparatus therefor, especially thought not exclusively to a method of providing a signal extension to a wavelet transformed signal of finite length, for example, in an image compression system. In particular, the invention can be utilised in an image compression system for performing subband coding of large images partitioned (segmented) into non-overlapped tiles or partially overlapped tiles.

Background of the Invention

One of the most efficient techniques for image compression is subband coding, such as wavelet transformation, where an image input signal is decomposed into several frequency subbands that are quantised and then coded for onward transmission or storage. Since this process is reversible, the original image signal can be reconstructed back from the coded subband information. An important practical problem in subband signal coding is that a high degree of complexity is introduced by decomposition/reconstruction when the signal length is substantial. This is especially critical for large images. The most commonly used approach to cope with this problem is to break an image into sub-images, known as blocks or tiles, of a smaller size and process them independently. This method, which is usually called non-overlapped tiling, can significantly reduce the complexity, but introduces very noticeable boundary artefacts in the regions of the edges of the tiles in the reconstructed image. Since a human eye is very sensitive to edges especially in uniform areas, these types of distortions are very noticeable and consequently degrade image quality dramatically. The problem of smooth boundary reconstruction is, of course, not limited to image coding, but in different aspects exists in many other applications.

Due to its practical importance the problem of reducing boundary artefacts has been extensively investigated and described in many publications. One known approach is to use overlapping samples from the adjacent tiles, as suggested by Il Kye Eom, Yoon Soo Kim and Jae Ho Kim in an article entitled “A Block Wavelet Transform for Sub-image Coding/Decoding” published in SPIE Vol. 2669 pp.169-177 and in US Patent No. 5,710,835. Another known approach is to employ a variety of post processing techniques at the image reconstruction stage, as described by B Jeon and J Jeong in an article entitled “Blocking Artifacts Reduction in Image Compression with Block Boundary Discontinuity Criterion” published in IEEE Trans. on Circuits and Systems for Video Tech. Vol 8, N3, 1998, pp 345-367 and by J K Su

and R M Mersereau in an article entitled "Post-processing for Artifact Reduction in JPEG-compressed Images" published in ICASSP-95, Vol. 4, pp. 2363-2366.

A further known approach is to extend the image data for each block during processing, so that the processing done on the edges of the block uses the extended data to provide fewer edge discontinuities. This approach is described in more detail in an article entitled "A Development of Symmetric Extension Method for Subband Image Coding" by H Kiya, K Nishikawa, M Iwahashi published in IEEE Transaction on Image Processing Vol.3, N1, 1994, pp. 78-81 and in US Patent 5,381,354.

Unfortunately, most existing methods can only be applied in practical systems with great difficulty due to the substantial additional complexity which they introduce.

Brief Summary of the Invention

The present invention therefore seeks to provide method of providing an extension to a signal and to apparatus therefor, which overcomes, or at least reduces, the above-mentioned problems of the prior art.

Accordingly, in a first aspect, the invention provides a method of providing an extension to at least one end of a signal, the extension being formed by the steps of:

defining a point at the at least one end of the signal;

determining a length of the signal starting from the defined point;

duplicating the determined length in a point symmetric fashion about the defined point so as to provide an extension of the signal beyond the at least one end

In a preferred embodiment, signal extensions are provided at both ends of the finite length signal. It will be appreciated that the finite length signal could be image data, or could be other data such as speech or other acoustic data, or other data. According to a second aspect of the present invention, there is provided a method of extending a signal having at least a first end, the method comprising the steps of:

defining a symmetry point at least adjacent the first end;

determining a portion of the signal adjacent to the defined symmetry point;

duplicating the determined portion of the signal in a point symmetric fashion about the defined symmetry point; and

extending the signal from the defined symmetry point using the duplicated portion of the signal.

In one embodiment, the defined symmetry point is at the first end of the signal. Alternatively, the defined symmetry point may be adjacent the first end of the signal and either on the signal side of the first end or external thereto.

Preferably, the signal is a digital signal comprising a sequence of discrete digital samples, the sequence having first and second ends with first and final discrete digital samples at the first and final ends.

It will be appreciated that the length of the signal can be determined along a horizontal axis of any desired domain in which the signal is available, for example, the domain could be a time domain or a frequency domain.

In a third aspect, the invention provides a method of subband image decomposition comprising the steps of:

receiving a sequence of image data for a block of an image that has been divided into a plurality of blocks;

extending the sequence of image data by, for each end of the sequence:

defining a symmetry point at each end;

determining a portion of the signal adjacent to each defined symmetry point;

duplicating the determined portion of the signal in a point symmetric fashion about each defined symmetry point; and

extending the signal from each defined symmetry point using the respective duplicated portion of the signal; and

decomposing the extended image data to provide subband decomposed image data.

Preferably the step of decomposing the extended image data comprises transforming the extended image data using a transform, such as a wavelet transform.

In a fourth aspect, the invention provides a method of compressing images comprising the steps of:

receiving image data representing at least one block of an image which has been divided into blocks;

decomposing the received image data utilising a method of subband image decomposition according to claim 21 to provide low pass and high pass subband decomposed image data;

quantising the low pass and high pass subband decomposed image data; and

coding the quantised low pass and high pass subband decomposed image data to provide compressed image data.

In a fifth aspect, the invention provides a method of image tile reconstruction comprising the steps of:

receiving at least two subband sequences of decomposed image data;

extending each of the subband sequences of decomposed image data utilising the method of extending a signal as described above to provide extended subband sequences; and

performing subband synthesis on the extended subband sequences to produce a reconstructed image tile.

In other aspects, the invention provides apparatus for carrying out the methods mentioned above.

Brief description of the drawings

One embodiment of the invention will now be more fully described, by way of example, with reference to the drawings, of which:

FIG. 1 shows a simplified block diagram of a well-known two-channel one-dimensional analysis and synthesis filter bank.

FIG. 2 shows a sequence of data samples in a sequence of finite length having extensions produced using a common symmetric method;

FIG. 3 shows a graph of an example of a signal across an image block, reconstructed using the conventional symmetric method and the new point-symmetric method according to the invention;

FIG. 4 shows sequences of data samples using point-symmetric extension for whole-sample and half-sample types of symmetry;

FIG. 5 shows a graph of a signal adjacent one of its boundaries to illustrate the differences between the point-symmetric and conventional symmetric extensions;

FIG. 6 shows sequences of data samples to illustrate subband analysis and synthesis of odd-length sequences using odd-length filters;

FIG. 7 shows sequences of data samples to illustrate subband analysis of even-length sequences using odd-length filters;

FIG. 8 shows a block diagram of an apparatus for performing one-dimensional subband decomposition of sequences according to an embodiment of the present invention; and

FIG. 9 shows a block diagram of an apparatus for performing one-dimensional subband reconstruction of sequences according to an embodiment of the present invention.

Detailed description of the invention

As is known, subband decomposition can be applied to images in a number of different ways depending on the application. Nevertheless, most of the known methods are based on similar analysis/synthesis operations, such as the one schematically presented in FIG. 1. As shown in FIG. 1, there are, in general, two sections in such a subband decomposition system 10. Thus, an input sequence of data X[n] is first received at an input 1 and then analysed in a first analysis section having two filters: a first low pass filter $\mathbf{H_0}$ 2 and a first high pass filter $\mathbf{H_1}$ 3. From the analysis section, the results of the analysis can be stored or transmitted to a synthesis section, which also includes two filters: a second low pass filter $\mathbf{G_0}$ 6 and a second

high pass filter $\mathbf{G_1}$ 7. The output of the synthesis section is an output sequence of data Y[n] at an output 9.

Thus, the input sequence X[n] from the input 1 is passed through two parallel paths, with one path having the low pass filters $\mathbf{H_0}$ 2 and $\mathbf{G_0}$ 6 and the second path having the high pass filters $\mathbf{H_1}$ 3 and $\mathbf{G_1}$ 7. The low and high pass components from the first low and high pass filters $\mathbf{H_0}$ 2 and $\mathbf{H_1}$ 3 are downsampled by a factor of two, in first and second downsamplers 11 and 12, respectively, to produce a low frequency subband L[n] and a high frequency subband H[n]. The low frequency subband L[n] and the high frequency subband H[n] can be used for further decomposition or can be quantised directly. The decomposed and, if desired, quantised information is then transmitted or otherwise passed to the synthesis section to reconstruct the original data. At the synthesis stage the subbands L[n] and H[n] are first upsampled by a factor of two in first and second upsamplers 13 and 14, respectively. They are then low and high pass filtered by low pass filter $\mathbf{G_0}$ 6 and high pass filter $\mathbf{G_1}$ 7. Finally, both subbands are summed by adder 8 to produce the output sequence Y[n] at an output 9. This output sequence Y[n] would be equal to X[n] if the operation had the property of perfect reconstruction. Of course, in practise, the components used may not be perfect and therefore the output sequence may not be identical to the input sequence.

A broad class of linear filters such as Quadrature Mirror Filters (QMF), Conjugate Quadrature Filters (CQF) and wavelets can be used as filters $\mathbf{H_0}$, $\mathbf{H_1}$, $\mathbf{G_0}$ and $\mathbf{G_1}$. However, regardless of the filter type, a proper extension of the input sequences X[n], L[n] and H[n] must be applied in order to perform the convolution properly. Very good results can be achieved by using a known symmetric extension, such as that shown schematically in FIG. 2. It is based on a mirror symmetry and the supplementary samples x[i] (shown by dotted lines) are easily found by copying the signal samples X[i] (shown by solid lines) about a first axis of symmetry 16 at one end of the received sequence and a second axis of symmetry 17 at a second end, as illustrated by arrows 15. This operation can be expressed by a formula:

$$\mathbf{x[i] = X[i]} \tag{1}$$

where $\mathbf{i = [1, \ldots, k]}$ for odd-length filters, or $\mathbf{i=[0, \ldots, k-1]}$ for even-length filters, where $\mathbf{k}$ is the number of samples required to extend the sequence.

Even though this extension is more efficient than a known periodic one (where the signal is simply repeated at the extension) and is currently employed in most subband systems, it causes boundary artifacts when images are tiled, as shown in FIG. 3. In FIG. 3, there is shown a portion of an image signal, where the narrow solid line 18 shows the original signal extending over a three tiles, of which one is shown complete (Tile 2) and adjacent tiles (Tiles 1 and 3) are shown partly. The bold line 19

shows a reconstructed signal reconstructed using the known mirror symmetric extension and shows how the reconstructed signal is discontinuous at the boundaries of the tiles. The dotted line 20 shows the reconstructed signal reconstructed using a point symmetric method according to an embodiment of the present invention to be described more fully below and clearly shows that the discontinuity at the boundaries is substantially reduced, as compared to the mirror symmetric extension method. This disadvantage of the conventional mirror symmetric approach can also be seen in FIG. 2, where there is no smooth transition between the original and extended portions of the sequence. Instead, sharp peaks may be produced, as around X[0] for example, that badly affect the final reconstructed image after compression.

To overcome the problems, an embodiment of the present invention proposes generating the extensions using a different type of symmetry, called herein "point-symmetric" since it uses a different type of symmetry from the mirror symmetry described above. In point symmetry, the signal, or line in the case of a drawing, for example, each point on the original is "mirrored" about a defined point of symmetry, rather than about a line (axis) of symmetry. So, each point on the original is translated to a point such that a straight line extending between the original point and the translated point has the point of symmetry at its mid point. An example of the point symmetric extension is shown in FIG. 4. As shown, the supplementary samples x[i] (shown by dotted lines) are produced from the signal samples X[i] (shown by solid lines) by arrows 27 passing through a point of symmetry 25. It will be appreciated that, in this case, two types of point symmetry are possible: whole-sample (WS) and half-sample (HS). In the first case, as shown in FIG. 4 (a), the point of symmetry 25 is on a sample 22 and 24. In the second case, the point of symmetry 25 is positioned on an imaginary sample 21 and 23 located halfway between two real samples or, as shown in FIG. 4 (b), at half the sampling period beyond the end sample, so that it is effectively outside the signal being extended. Thus, the difference between these types of symmetry can be considered as a difference in the positioning of the point of symmetry 25.

A simple formula can be used to calculate the point symmetric extension x[n] at the beginning and at the end of X[n]:

$$\mathbf{x[i] = 2 * P - X[i]}, \qquad (2)$$

where **i = [1,..., k]** for WS point symmetry, or **I = [0, ..., k-1]** for HS point symmetry, where **P** is the value of the corresponding point of symmetry being used. For digital samples, as here, the value of **P** is simply the value of the sample, real or imaginary, on which the point of symmetry is located. For a more general case, **P** is the vector value from some common origin. In the case of the digital samples here, of course, the common origin is the horizontal axis. Of course, although the point of symmetry

is shown in FIG. 4 as being at the highest value end of the particular sample, it could be anywhere on the sample, or, as with the imaginary samples, off the sample.

If the sequence of data samples X[n] is to be extended at its beginning, the starting point of symmetry is located on sample X[0]. The point of symmetry at the other end of the signal sequence is the last sample X[n] (which is X[7] in the example shown in FIG. 4). The minimum number of extension samples required is equal to the number of filter coefficients falling beyond the end of the original sequence when the filter is positioned at the starting or terminating sample, that is, the filters require a number of samples, either side of the sample being filtered in order to produce a result. That number is filter dependent. Although this rule is similar to the one for conventional extension, the required number of extension samples can be smaller, because the starting/terminating sample can be located not at the tile boundary. This will be illustrated by an example below.

The difference between the two extensions applied to the same signal 26 is illustrated in FIG. 5. It can be seen that the conventional mirror symmetric extension 29 (shown by dotted line) produces an artificial sharp peak 30 at the signal boundary 31, while the point-symmetric extension 32 creates a much smoother join 28 by eliminating the slope discontinuity.

Similarly to the conventional mirror symmetric method, the proposed point symmetric approach operates slightly differently for odd length filters, as compared to even length filters and for odd length sequences, as compared to even length sequences. An example of data flow in an odd length analysis/synthesis filter bank applied to an odd length sequence is illustrated in FIG. 6. In the first stage (FIG. 6 (a)), an input sequence of data samples X[n] is point symmetrically extended in the manner described above to provide an extended sequence of samples x[n]. After applying subband analysis, two sequences L[n] and H[n] are produced, which are illustrated in FIG. 6 (b) and FIG. 6 (c), respectively. The overall number of subband samples (L[n] and H[n]) is equal to the number of input samples X[n] and the low pass subband L[n] always contains one more sample than the high pass subband H[n]. At the synthesis stage (FIG. 6 (d) and (e)), the extension samples x[n] are produced using the same point symmetric method as described above, except that, in the low pass subband, the point of symmetry is at the value of the beginning and terminating subband samples L[0] and L[4], respectively, whereas in high-band H[n] the point of symmetry is located half a sampling period beyond (outside) the beginning and terminating samples and is equal to 0. This means that, as can be seen in FIG. 6 (d), the low pass subband extensions use WS symmetry, but the high pass extensions, as shown in FIG. 6 (e), use HS symmetry to form the extension.

The final result of the analysis produces the output sequence Y[n], as shown in FIG. 6 (f), has the same number of samples as the input sequence X[n]. It should be noted that for many wavelet filters this point symmetric method produces L[0] = X[0] and L[M] = X[N], where M and N are the maximum indexes of L[n] and X[n] correspondingly. This feature permits a reduction by a factor of two in the number of convolution operations in the low band channel and a reduction in the number of extension samples required in the first place.

In the case of even-length sequences, data reordering is required to preserve the perfect reconstruction property of the filter bank. Although reordering can be carried out in a number of ways it always aims to add missing information about one of the points of symmetry **P** to the output. An example of data flow in an odd-length analysis/synthesis filter bank applied to an even-length sequence is illustrated in FIG. 7. As with the odd length sequence described above with reference to FIG. 6, an input sequence of data samples X[n] is point symmetrically extended in the manner described above to provide an extended sequence of samples x[n] (see FIG. 7 (a)). After applying subband analysis, two sequences L[n] and H[n] are produced, which are illustrated in FIG. 7 (b) and FIG. 7 (c), respectively. However, due to the point symmetric extension of X[n], the last sample in the high pass subband is always equal to zero and therefore does not need to be stored (see FIG. 7 (c)). Thus, this position can be used to store additional information helpful for lossless reconstruction. One possible use of this is illustrated in FIG. 7 (d), where a new sample H[3] is produced by subtracting sample L[3] from sample X[7], as illustrated by arrow 32. Sample L[3] in the low pass subband is also replaced by sample X[7], as shown by arrow 33 in FIG. 7 (e). After this rearrangement, both subbands contain the same number of samples.

During the synthesis operation, backward data reordering is required. Firstly, the value of sample L[3] is taken to be the value for the point of symmetry of the final end of the low pass subband sequence L[n], as shown by arrow 34 in FIG. 7 (g). The location of this point of symmetry is set to be half a sampling period beyond (outside) the final sample L[3]. Then, sample L[3] is replaced by the sum of samples L[3] and H[3], as shown by arrow 35 in FIG. 7 (g) and sample H[3] is set to zero, as shown in Fig. 7 (f). The point of symmetry for the first end of the low pass subband is at the first low pass sample L[1] and the point of symmetry of the final end of the high pass subband is at the final high pass sample H[3], which is, as mentioned above, set to zero. The point of symmetry for the first end of the high pass subband is set to be half a sampling period beyond (outside) the first sample H[0]. Finally, the sequences L[n] and H[n] are extended, filtered and summed together to produce Y[n]. It is important to note that, in this embodiment, for the low pass subband L[n], WS point symmetry

is used at the start and LS point symmetry is used at the end, while for the high pass subband H[n], HS point symmetry is used at the start and WS point symmetry is used at the end, as shown in FIG. 7 (f) and FIG. 7 (g). If quantisation is not applied to L[n] and H[n], then the output Y[n] = X[n], because this method preserves the perfect reconstruction property.

A block diagram of apparatus 100 implementing subband decomposition is shown in FIG.8. Information regarding low-pass filter length is applied to a first input 112 and information regarding high-pass filter length is applied to a second input 114 of an extension samples counter 102. As described above, the extension samples counter 102 calculates the number of extension samples **k**, that are required for the particular lengths of the low pass and high pass filters from the information provided at inputs 112 and 114. The value of **k**, together with information regarding the type of point extension required (WS or HS depending on the length of the filters) is provided at an output from the counter 102 and passed to a first input 118 of an extension samples generator 104. A point of symmetry selector 106 receives a sequence of data samples X[n] provided at input 116. The point of symmetry selector 106 generates values **P** corresponding to the starting and terminating points of symmetry from the starting and the terminating samples of the input sequence X[n] and passes them to a second input 120 of the extension samples generator 104. The input sequence X[n] is also sent to a third input 122 of the extension samples generator 104. The extension samples generator 104 generates extension samples x[n] using formula (2) described above. These extension samples x[n] are passed to a second input 126 of an analysis filter bank 108. A first input of the analysis filter bank 108 receives the input sequence X[n] and together with the extension samples x[n] from second input 126, the full extended sequence is subband decomposed according to the method described above with reference FIG.6 (b-c) and FIG.7 (b-c). The analysis filter bank 108 provides two outputs, which consist of a low-pass band at a first output 128 and a high-pass band at a second output 134. The first and second outputs of the analysis filter bank 108 are passed to first and second inputs of a data reordering unit 110. Information regarding the signal length is applied to a third input 130 of the data reordering unit 110. If the signal length is odd (as shown in FIG. 6), then the data reordering unit 110 simply passes the sequences at its inputs straight through to its outputs 136 and 138. If, on the other hand, the signal length is even, data reordering is performed as described above with reference to FIG. 7. One example of such reordering is shown in FIG. 7 (d-e). The low pass and high pass subband sequences L[n] and H[n] from the outputs 136 and 138 of the data reordering unit 110 provide the output of the apparatus 100, as shown in FIG.6 (b-c) when the input sequence X[n] is odd length, or in FIG. 7 (d-e) when the input sequence X[n] is even-length.

FIG. 9 shows a block diagram of apparatus 140 implementing the subband reconstruction. Thus, the low pass and high pass subband sequences L[n] and H[n] which were previously generated by apparatus 100 and subsequently stored or transmitted are applied at two inputs 142 and 144 of a data reordering unit 146. Information regarding the lengths of the low-pass and high pass filters $\mathbf{H_0}$ and $\mathbf{H_1}$ are applied to a first and second inputs 150 and 152 of an extension samples counter 148. The extension samples counter 148 calculates the extension types for each channel and the number of required extension samples **k-low** and **k-high**. The value of **k-low** coupled with the extension type are passed from the first output 154 of the extension samples counter 148 to a first input 156 of a low-band extension samples generator 158. At a second input 160 of the extension samples counter 148 are supplied two point of symmetry values **P** for the starting and terminating points of symmetry of the sequence. These two point of symmetry values are provided from a point of symmetry selector 162, which retrieves those values from the starting and the terminating samples of the low pass subband input sequence L[n] from input 142. The point of symmetry values **P** are used only in the low-pass channel, because the points of symmetry in the high-pass channel are always equal to zero.

The data reordering unit 146 receives information regarding the signal length at a third input 164 and performs inverse reordering (see for example FIG.7 (f-g) on the low pass and high pass subband sequences L[n] and H[n]. Then the reordered low-pass samples L[n] are passed to a first input 166 of a synthesis filter bank 170 and to a third input 168 of the low-band extension samples generator 158. The reordered high-band samples H[n] are passed to a second input 172 of the synthesis filter bank 170 and to a first input 174 of a high-band extension samples generator 178. The high-band extension samples generator 158 also receives the value of **k-low** coupled with the extension type at a second input 176 from a second output 180 of the extension samples counter 148. The extension samples are calculated separately in the low-band extension samples generator 158 and high-band extension samples generator 178. The low-pass subband extensions l[n] generated by the low-band extension samples generator 158 are passed to a third input 182 of the synthesis filter bank 170 and the high-pass subband extensions h[n] are sent to a fourth input 184 of the synthesis filter bank 170. The synthesis filter bank 170 uses the low-pass subband extensions l[n] and the high-pass subband extensions h[n] together with the reordered low-pass samples L[n] and reordered high-pass samples H[n] from the first and second inputs 166 and 172 to perform signal reconstruction. The result of the reconstruction **Y[n]** (see FIG. 6 (f)) is provided at an output 186 of the synthesis filter bank 170, which is also the output of the apparatus 140.

From the above description, it will be apparent that, in comparison with the conventional mirror symmetric extension method, the proposed point symmetric extension method minimises the deviation at the tile boundaries of the reconstructed sequences, thus reducing boundary artefacts and producing smoother joints between the original signal and the extension by eliminating slope discontinuity, thus leading to compression improvement.

It will be apparent that although only one particular embodiment of the invention has been described in detail, various modifications and improvements can be made by a person skilled in the art without departing from the scope of the present invention.

For example, it is known from a paper entitled "Classification of Nonexpansive Symmetric Extension Transforms for Multirate Filter Banks" by Christopher M. Brislawn published in Applied and Computational Harmonic Analysis, Vol. 3, pp. 337-357 (1996) that a signal extension technique is equivalent to a time-varying boundary filter, so that the output of a non-varying filter having the extended signal as an input is the same as the output of the time-varying filter having the non-extended signal as an input. Consequently, although the embodiment of the invention has been described above in terms of signal extension, it will be apparent that this is equivalent to time varying an appropriate filter.

Claims

1. A method of providing an extension to at least one end of a signal, the extension being formed by the steps of:

defining a point at the at least one end of the signal;

determining a length of the signal starting from the defined point;

duplicating the determined length in a point symmetric fashion about the defined point so as to provide an extension of the signal beyond the at least one end.

2. A method of providing an extension to at least one end of a signal according to claim 1, wherein the signal extension is provided at both ends of the signal.

3. A method of providing an extension to at least one end of a signal of finite length according to claim 1, wherein the signal includes at least one set of data from the group of data sets including:

image data set;

speech data set;

acoustic data. set.

4. A method of extending a signal having at least a first end, the method comprising the steps of:

defining a symmetry point at least adjacent the first end;

determining a portion of the signal adjacent to the defined symmetry point;

duplicating the determined portion of the signal in a point symmetric fashion about the defined symmetry point; and

extending the signal from the defined symmetry point using the duplicated portion of the signal.

5. A method of extending a signal according to claim 4, wherein the defined symmetry point is at the first end of the signal.

6. A method of extending a signal according to claim 4, wherein the defined symmetry point is adjacent the first end of the signal and on the signal side of the first end.

7. A method of extending a signal according to claim 4, wherein the defined symmetry point is adjacent the first end of the signal and external thereto.

8. A method of extending a signal according to claim 4, wherein the signal is a digital signal comprising a sequence of discrete digital samples, the sequence having first and second ends with first and final discrete digital samples at the first and final ends.

9. A method of extending a signal according to claim 8, wherein the defined symmetry point is located at the first end of the sequence and has a value at least close to the value of the discrete digital sample that is at the first end of the sequence.

10. A method of extending a signal according to claim 8, wherein the symmetry point is adjacent the first end of the sequence.

11. A method of extending a signal according to claim 8, wherein the symmetry point is located external of the first end of the sequence and has a value the same as a value of an adjacent discrete digital sample.

12. A method of extending a signal according to claim 8, wherein the symmetry point is located external of the first end of the sequence by an amount equal to half of a period between the discrete digital samples in the sequence.

13. A method of extending a signal according to claim 12, wherein the value of the defined symmetry point is zero.

14. A method of extending a signal according to claim 4, wherein the signal has first and second ends and the extension is provided at both ends of the signal.

15. A method of extending a signal according to claim 4, wherein the length of the signal is determined along a horizontal axis of a desired domain in which the signal is available.

16. A method of extending a signal according to claim 15, wherein the length of the signal is determined in a time domain.

17. A method of extending a signal according to claim 15, wherein the length of the signal is determined in a frequency domain.

18. A method of extending a signal according to claim 4, wherein the signal includes at least one set of data from the group of data sets including:

image data set;

speech data set;

acoustic data. set.

19. A method of subband image decomposition comprising the steps of:

receiving a sequence of image data for a block of an image that has been divided into a plurality of blocks;

extending the sequence of image data by, for each end of the sequence:

defining a symmetry point at each end;

determining a portion of the signal adjacent to each defined symmetry point;

duplicating the determined portion of the signal in a point symmetric fashion about each defined symmetry point; and

extending the signal from each defined symmetry point using the respective duplicated portion of the signal; and

decomposing the extended image data to provide subband decomposed image data.

20. A method of subband image decomposition according to claim 19, wherein the step of decomposing the extended image data comprises transforming the extended image data using a transform, such as a wavelet transform to produce decomposed image data.

21. A method of subband image decomposition according to claim 20, wherein the step of transforming the extended image data comprises transforming the image data through a high pass transform filter to produce high pass subband decomposed image data and transforming the image data through a low pass transform filter to produce low pass subband decomposed image data.

22. A method of subband image decomposition according to claim 21, wherein the sequence of image data has an even number of data samples and both the high pass and the low pass subband decomposed image data have even numbers of data samples.

23. A method of subband image decomposition according to claim 22, wherein a final data sample of the high pass subband decomposed image data samples has a value of zero.

24. A method of subband image decomposition according to claim 21, wherein the sequence of image data has an odd number of data samples, the low pass subband decomposed image data has an odd numbers of data samples and the high pass subband decomposed image data has an even number of data samples.

25. A method of compressing images comprising the steps of:

receiving image data representing at least one block of an image which has been divided into blocks;

decomposing the received image data utilising a method of subband image decomposition according to claim 21 to provide low pass and high pass subband decomposed image data;

quantising the low pass and high pass subband decomposed image data; and

coding the quantised low pass and high pass subband decomposed image data to provide compressed image data.

26. A method of method of compressing images according to claim 25, wherein both the high pass and the low pass subband decomposed image data have even numbers of data samples and wherein the final data sample of the high pass subband decomposed image data sequence is replaced by a data sample formed from a combination of original image data and decomposed image data.

27. A method of method of compressing images according to claim 26, wherein the final data sample of the high pass subband decomposed image data sequence is replaced by a data sample formed by the subtraction of the final data sample of the low pass subband decomposed image data sequence from the final data sample of the received sequence of image data.

28. A method of image tile reconstruction comprising the steps of:

receiving at least two subband sequences of decomposed image data;

extending each of the subband sequences of decomposed image data utilising the method of extending a signal according to claim 14 to provide extended subband sequences; and

performing subband synthesis on the extended subband sequences to produce a reconstructed image tile.

29. A method of image tile reconstruction according to claim 28, wherein low pass and high pass subband sequences of decomposed image data are received.

30. A method of image tile reconstruction according to claim 29, wherein the low pass subband sequence of decomposed image data has an odd number of data samples and the high pass subband sequence of decomposed image data has an even number of data samples.

31. A method of image tile reconstruction according to claim 30, wherein the step of extending the low pass subband sequence of decomposed image data comprises defining the points of symmetry to be located at respective ends of the low pass sequence and to have a respective value that is the same as the value of the sample that is at the respective end of the sequence.

32. A method of image tile reconstruction according to claim 30, wherein the step of extending the high pass subband sequence of decomposed image data comprises defining the points of symmetry to be located external of the respective ends of the sequence by an amount equal to half of a period between the samples in the sequence and to have a respective value that is zero.

33. A method of image tile reconstruction according to claim 29, wherein both the high pass and the low pass subband sequences of decomposed image data have an even number of data.

34. A method of image tile reconstruction according to claim 33, wherein the step of extending the high pass subband sequence of decomposed image data comprises:

setting the final sample of the high pass subband sequence of decomposed image data to be zero;

defining a final point of symmetry to be located at the final sample and to have a value of zero; and

defining a first point of symmetry to be located external of the first end of the sequence by an amount equal to half of a period between the samples in the sequence and to have a value of zero.

35. A method of image tile reconstruction according to claim 33, wherein

the step of extending the low pass subband sequence of decomposed image data comprises:

defining a final point of symmetry to be located external of a final end of the sequence by an amount equal to half of a period between the samples in the sequence and to have a value equal to the final sample of the low pass subband sequence of decomposed image data;

replacing the final sample of the low pass subband sequence of decomposed image data by a sample formed by the addition of the final samples of the low pass and high pass subband sequences of decomposed image data; and

defining a first point of symmetry to be located at the first end of the low pass subband sequence and to have a value equal to the first sample of the low pass subband sequence of decomposed image data.

36. Apparatus for providing an extension to at least one end of a signal, the apparatus comprising:

receiving means for receiving the signal;

definition means coupled to the receiving means for defining a point at the at least one end of the signal;

determining means having a first input coupled to the receiving means and a second input coupled to the definition means for determining a length of the signal starting from the defined point and an output;

duplicating means having an input coupled to the output of the determining means for duplicating the determined length in a point symmetric fashion about the defined point and an output at which to provide an extension of the signal beyond the at least one end.

37. Apparatus for providing an extension to at least one end of a signal according to claim 36, wherein the signal extension is provided at both ends of the signal.

38. Apparatus for providing an extension to at least one end of a signal according to either claim 36 or claim 37, wherein the signal includes at least one set of data from the group of data sets including:

image data set;

speech data set;

acoustic data. set

39. Apparatus for extending a signal having at least a first end, the apparatus comprising:

defining means having an input for receiving the signal and an output for providing a defined symmetry point at least adjacent the first end of the signal;

determining means having an input coupled to the output of the defining means and an output for providing a determined portion of the signal adjacent to the defined symmetry point;

duplicating means having an input coupled to the output of the determining means and an output for providing a duplicate of the determined portion of the signal in a point symmetric fashion about the defined symmetry point;

extending means having an input coupled to the output of the duplicating means and an output for providing an extended signal using the duplicated portion of the signal.

40. Apparatus for extending a signal according to claim 39, wherein the symmetry point is at the first end of the signal.

41. Apparatus for extending a signal according to claim 39, wherein the symmetry point is adjacent the first end of the signal and on the signal side of the first end.

42. Apparatus for extending a signal according to claim 39, wherein the symmetry point is adjacent the first end of the signal and external thereto.

43. Apparatus for extending a signal according to claim 39, wherein the signal is a digital signal comprising a plurality of discrete digital samples, the sequence having first and second ends with first and last discrete digital samples at the first and final ends.

44. Apparatus for extending a signal according to claim 43, wherein the symmetry point is located at the first end of the sequence and has a value at least close to the value of the discrete digital sample that is at the first end of the sequence.

45. Apparatus for extending a signal according to claim 43, wherein the symmetry point is adjacent the first end of the sequence.

46. Apparatus for extending a signal according to claim 45, wherein the symmetry point is located external of the first end of the sequence and has a value the same as a value of an adjacent discrete digital sample.

47. Apparatus for extending a signal according to claim 46, wherein the symmetry point is located external of the first end of the sequence by an amount equal to half of a period between the discrete digital samples in the sequence.

48. Apparatus for extending a signal according to claim 47, wherein the value of the defined symmetry point is zero.

49. Apparatus for extending a signal according to claim 39, wherein the signal extension is provided at both ends of the signal of finite length.

50. Apparatus for extending a signal according to claim 39, wherein the signal includes at least one set of data from the group of data sets including:

image data set;

speech data set;

acoustic data. set.

51. Apparatus for extending a signal according to claim 39, wherein the length of the signal is determined along a horizontal axis of a desired domain in which the signal is available.

52. Apparatus for extending a signal according to claim 51, wherein the length of the signal is determined in a time domain.

53. Apparatus for extending a signal according to claim 51, wherein the length of the signal is determined in a frequency domain.

54. Apparatus for subband image decomposition comprising:

receiving means for receiving image data for an image that has been divided into a plurality of blocks;

apparatus for extending a signal according to claim 43 having an input coupled to the receiving means and an output to provide extended image data; and

decomposing means having an input coupled to the output of the apparatus for extending a signal and an output to provide subband decomposed image data.

55. Apparatus for subband image decomposition according to claim 54, wherein the decomposing means comprises transforming means for transforming the extended image data using a transform, such as a wavelet transform.

56. Apparatus for subband image decomposition according to claim 55, wherein the transforming means comprises a high pass transform filter to produce high pass subband decomposed image data and a low pass transform filter to produce low pass subband decomposed image data.

57. Apparatus for compressing images comprising:

receiving means for receiving image data representing at least one block of an image which has been divided into blocks;

apparatus for subband image decomposition according to claim 56 providing low pass and high pass subband decomposed image data;

quantisation means for quantising the low pass and high pass subband decomposed image data; and

coding means for coding the quantised low pass and high pass subband decomposed image data to provide compressed image data.

58. Apparatus for compressing images according to claim 57, wherein both the high pass and the low pass subband decomposed image data have even numbers of data samples and further comprising:

combining means for combining original image data and decomposed image data to provide combined data; and

replacing means for replacing the final data sample of the high pass subband decomposed image data sequence by a data sample formed from the combined data.

59. Apparatus for compressing images according to claim 58, wherein the combining means comprises a subtractor for subtracting the final data sample of the low pass subband decomposed image data sequence from the final data sample of the received sequence of image data.

60. Apparatus for image tile reconstruction comprising:

receiving means for receiving at least two subband sequences of decomposed image data;

apparatus for extending a signal according to claim 43 having an input coupled to the receiving means and an output to provide extended subband sequences; and

a subband synthesiser coupled to the output of the apparatus to synthesise a reconstructed image tile from the extended subband sequences.

61. Apparatus for image tile reconstruction according to claim 60, wherein low pass and high pass subband sequences of decomposed image data are received.

62. Apparatus for image tile reconstruction according to claim 61, wherein the low pass subband sequence of decomposed image data has an odd number of data samples and the high pass subband sequence of decomposed image data has an even number of data samples.

63. Apparatus for image tile reconstruction according to claim 61, wherein both the high pass and the low pass subband sequences of decomposed image data have an even number of data.

64. Apparatus for image tile reconstruction according to claim 63, wherein the apparatus for extending a signal comprises:

means for setting the final sample of the high pass subband sequence of decomposed image data to be zero;

means for defining a final point of symmetry to be located at the final sample and to have a value of zero; and

means for defining a first point of symmetry to be located external of the first end of the sequence by an amount equal to half of a period between the samples in the sequence and to have a value of zero.

65. Apparatus for image tile reconstruction according to claim 33, wherein the apparatus for extending a signal comprises:

means for defining a final point of symmetry to be located external of a final end of the sequence by an amount equal to half of a period between the samples in the sequence and to have a value equal to the final sample of the low pass subband sequence of decomposed image data;

means for replacing the final sample of the low pass subband sequence of decomposed image data by a sample formed by the addition of the final samples of the low pass and high pass subband sequences of decomposed image data; and

means for defining a first point of symmetry to be located at the first end of the low pass subband sequence and to have a value equal to the first sample of the low pass subband sequence of decomposed image data.

Abstract

A Method of Providing an Extension to a Signal and Apparatus Therefor

An sequence of data samples X[n] is point symmetrically extended to provide an extended sequence of samples x[n]. The points of symmetry (25) can be at the ends (17, 19) of the sequence (as in FIG. 4 (a)), such that the samples at the ends are not duplicated but the points of symmetry are at the values of those samples. Thus, the extensions are formed by duplications (27) of a predetermined number of the other samples. Alternatively (as shown in FIG. 4 (b)), the points of symmetry (25) can be a half-sampling rate beyond (23, 25) the samples at the ends of the sequence so that those samples are also duplicated (27) to provide the extensions. For tiled image data, image compression and reconstruction utilising the point symmetric technique provides a very good reconstructed image with reduced artifacts at the tile boundaries. For this, both locations of the points of symmetry mentioned above need to be utilised for different sequences depending on whether there are odd or even numbers of samples in the sequences and whether the filters used are odd or even in length.

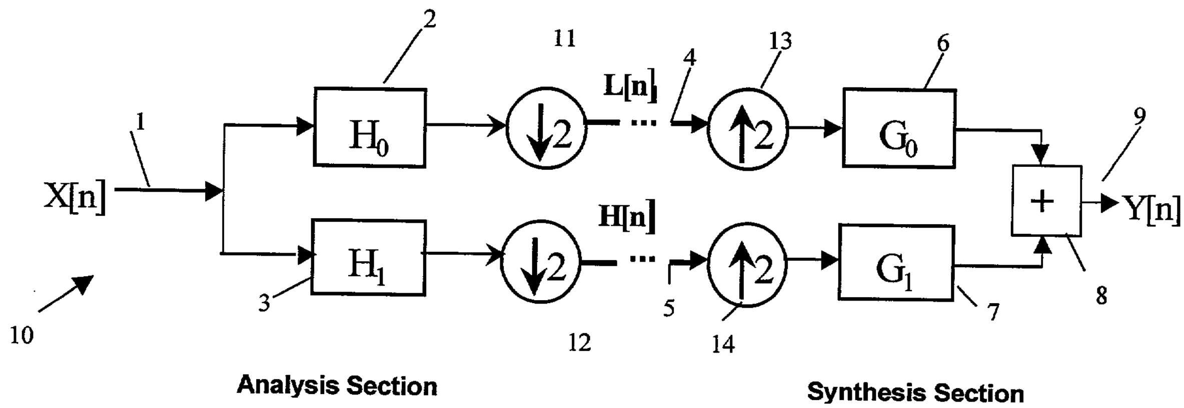

FIG. 1

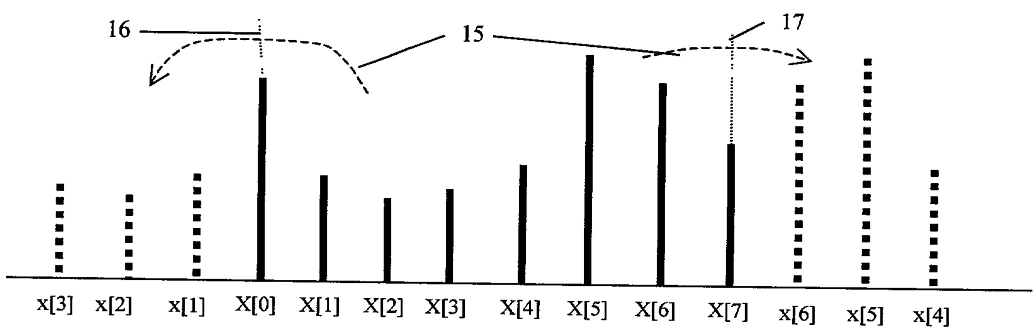

FIG. 2

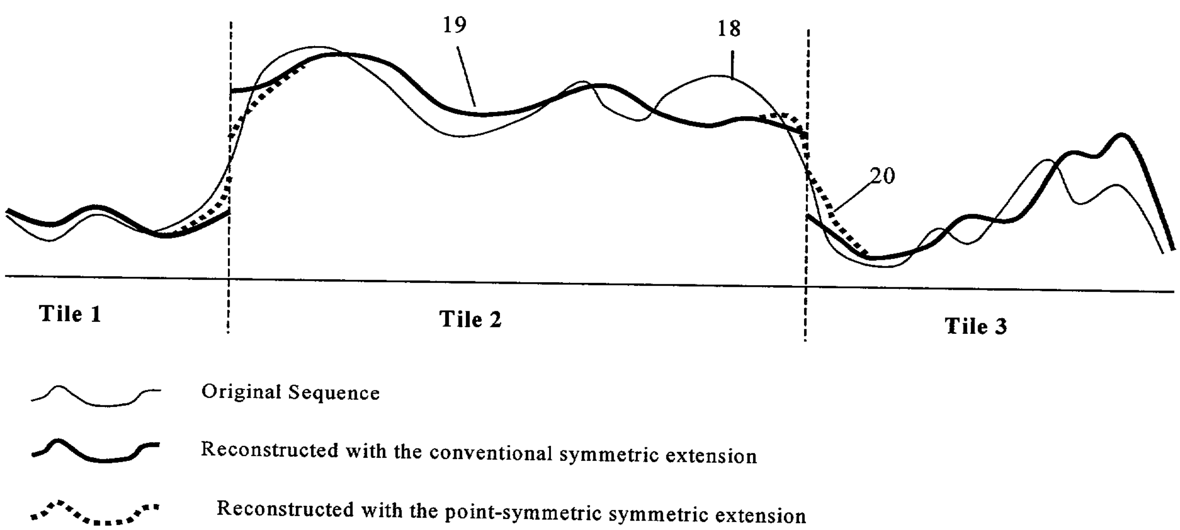

FIG. 3

09/890618

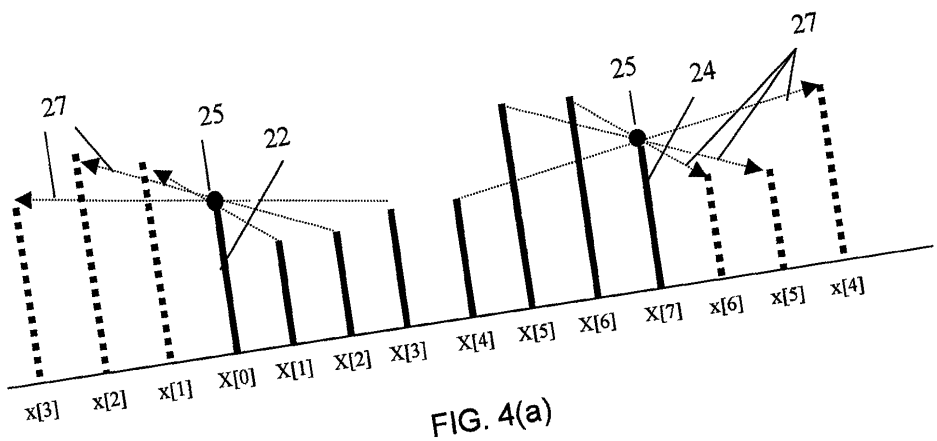

FIG. 4(a)

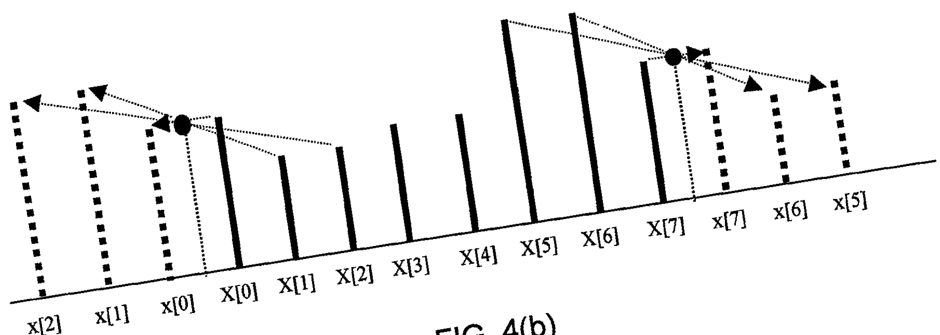

FIG. 4(b)

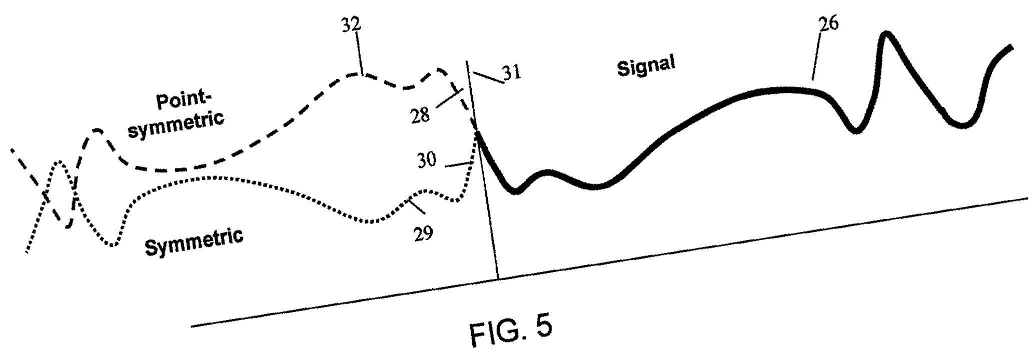

FIG. 5

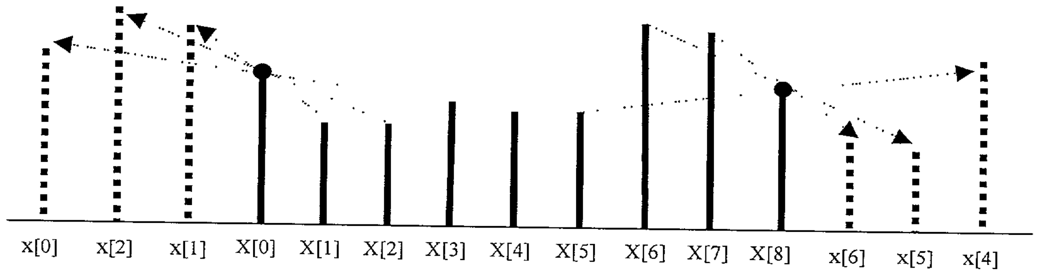

FIG. 6(a)

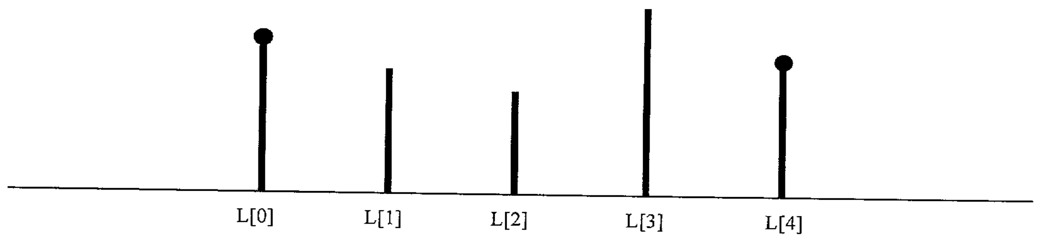

FIG. 6(b)

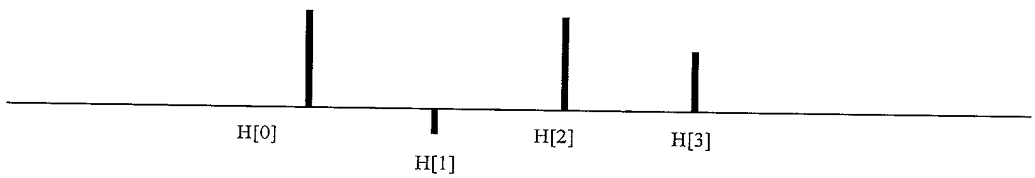

FIG. 6(c)

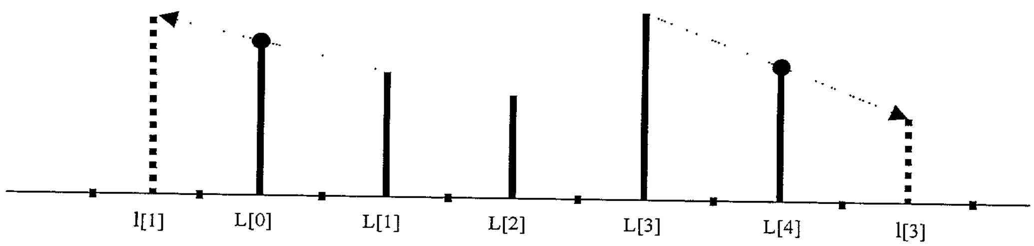

FIG. 6(d)

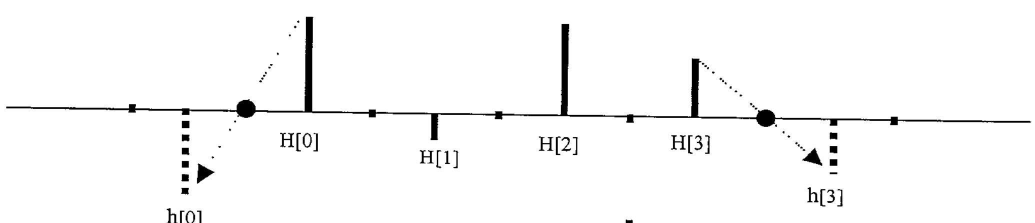

FIG. 6(e)

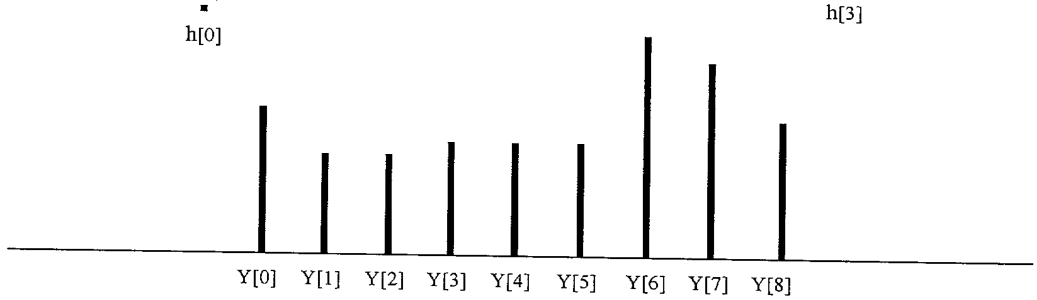

FIG. 6(f)

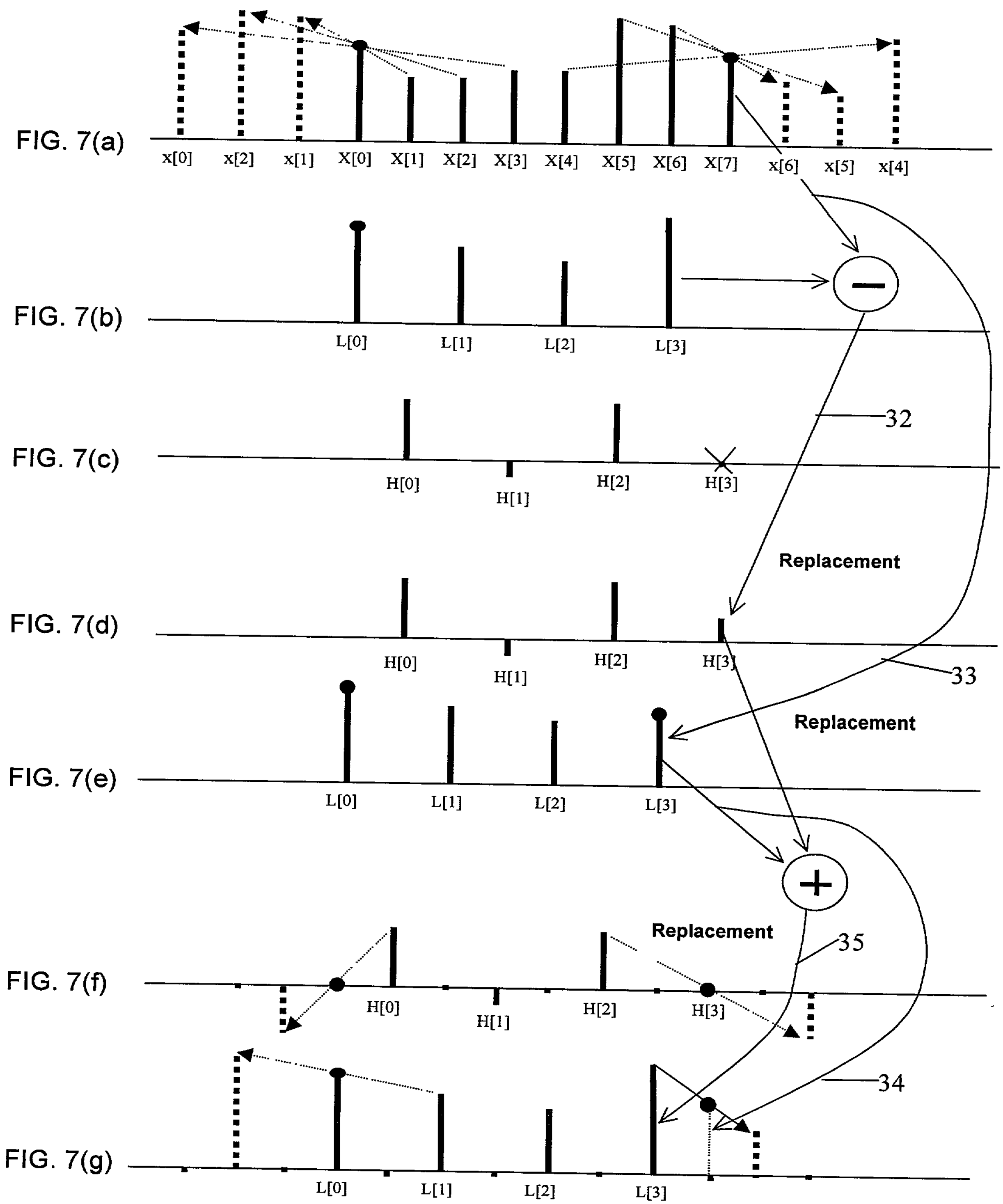
FIG. 7(a)
x[0] x[2] x[1] X[0] X[1] X[2] X[3] X[4] X[5] X[6] X[7] x[6] x[5] x[4]
FIG. 7(b)
L[0] L[1] L[2] L[3]
FIG. 7(c)
H[0] H[1] H[2] H[3]
32
Replacement
FIG. 7(d)
H[0] H[1] H[2] H[3]
33
Replacement
FIG. 7(e)
L[0] L[1] L[2] L[3]
Replacement
35
FIG. 7(f)
H[0] H[1] H[2] H[3]
34
FIG. 7(g)
L[0] L[1] L[2] L[3]

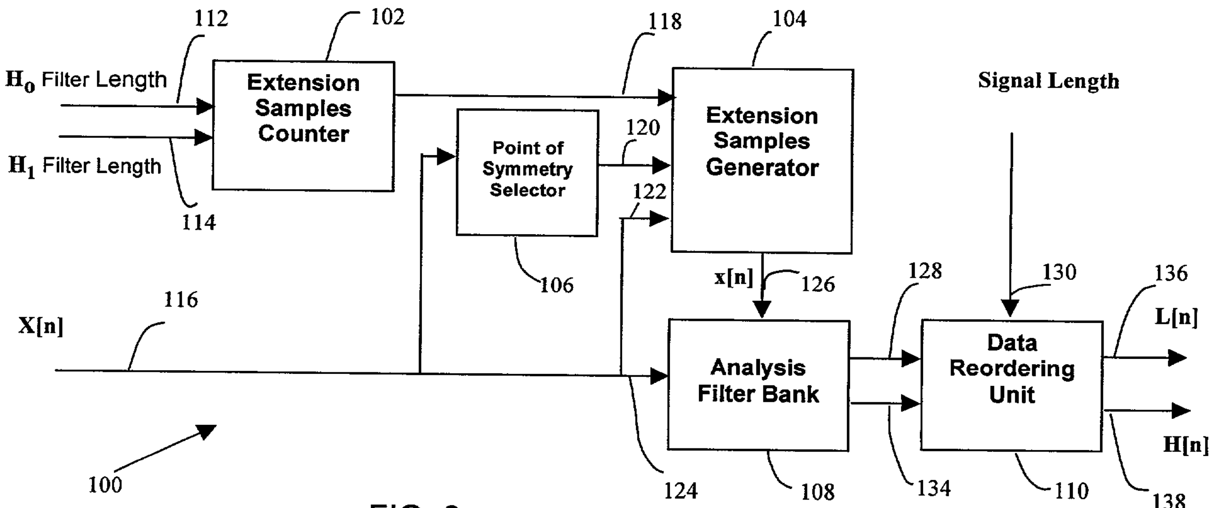
112
102
118
104
H_0 Filter Length
Extension Samples Counter
Extension Samples Generator
Signal Length
H_1 Filter Length
Point of Symmetry Selector
120
122
114
106
x[n]
126
128
130
136
116
L[n]
X[n]
Analysis Filter Bank
Data Reordering Unit
H[n]
100
124
108
134
110
138

FIG. 8

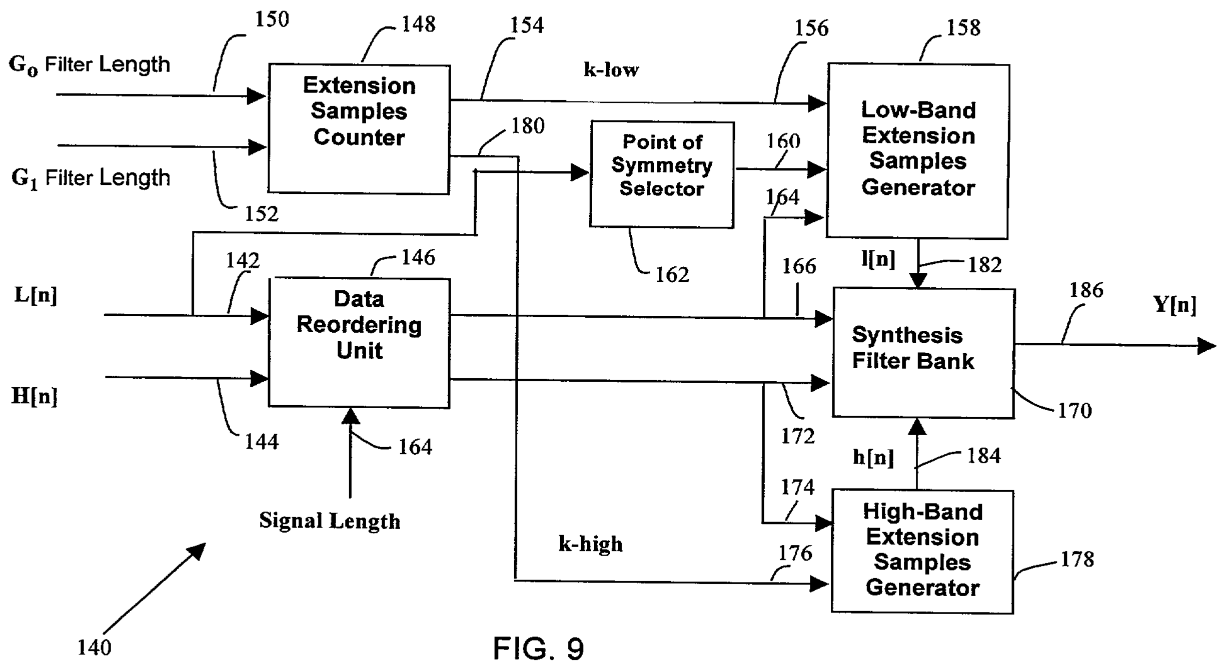
150
148
154
156
158
G_0 Filter Length
Extension Samples Counter
k-low
Low-Band Extension Samples Generator
180
Point of Symmetry Selector
160
G_1 Filter Length
164
152
142
146
166
l[n]
182
162
L[n]
Data Reordering Unit
186
Y[n]
Synthesis Filter Bank
H[n]
144
164
172
170
h[n]
184
174
Signal Length
High-Band Extension Samples Generator
k-high
176
178
140

FIG. 9

PATENT APPLICATION DECLARATION
COMBINED WITH POWER OF ATTORNEY

Attorney's Docket No.: CR1028AC

[X] Regular (Utility) [ ] Design Application

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

A METHOD OF PROVIDING AN EXTENSION TO A SIGNAL AND APPARATUS THEREFOR

the specification of which:

[X] is attached hereto [ ] was filed on: ____________

as U.S. Serial No.: ____________

and was amended on ____________

(if applicable)

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, Section 1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d), of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign/PCT Application(s):

[ ] no such application(s) filed [X] such application(s) identified as follows:

Application Number	Country	Date of Filing *(day, month, year)*	Priority Claimed Under 37 U.S.C. 119
PCT/IB00/00102	PCT	2 FEBRUARY 2000	[X] Yes [ ] No
			[ ] Yes [ ] No

I hereby claim the priority benefit under Title 35, United States Code, Section 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, Section 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, Section 1.56(a) which is material to the patentability of this application and which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

Prior U.S. Application(s):

☒ no such application(s) filed

☐ such application(s) identified as follows:

Application No.	Filing Date *(day, month, year)*	Status *(Patented, Pending, Abandoned)*

I hereby declare that: as to any claimed subject matter of this application which is common to my earlier United States or foreign application(s), if any, which I have identified above and claimed the benefit of priority thereof, I do not believe that the same was ever known or used in the United States before my invention thereof or patented or described in any printed publication in any country before my invention thereof or more than one year prior to the first of said earlier application(s), or in public use or on sale in the United States more than one year prior to the first of said earlier application(s), and that the said common subject matter has not been patented or made the subject of an inventor's certificate before the date of the first of said earlier U.S. application(s) in any country foreign to the United States on an application, filed by me or my legal representatives or assigns more than twelve months (six months if the present application is a Design patent application) prior to the first of said earlier U.S. application(s), if any; and that, as to any claimed subject matter of this application which is not common to said earlier application(s), if any, I do not know and do not believe that the same was ever known or used in the United States before my invention thereof or patented or described in any printed publication in any country before my invention thereof or more than one year prior to the date of this application, or in public use or on sale in the United States more than one year prior to the date of this application, and that said subject matter has not been patented or made the subject of an inventor's certificate in any country foreign to the United States on an application filed by me or my legal representatives or assigns more than twelve months (six months if the present application is a Design patent application) prior to the date of this application.

I HEREBY APPOINT THE ATTORNEY(S) OR AGENT(S) ASSOCIATED WITH:

CUSTOMER NUMBER 22917

TO PROSECUTE THIS APPLICATION AND TRANSACT ALL BUSINESS IN THE PATENT AND TRADEMARK OFFICE CONNECTED THEREWITH.

Send correspondence to:

Jonathan P. Meyer
MOTOROLA, INC.
1303 East Algonquin Road
Schaumburg, IL 60196

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

CR1028AC

FULL NAME OF FIRST-NAMED OR SOLE INVENTOR: FIRST MIDDLE LAST	INVENTOR'S SIGNATURE:	DATE: (SPELLOUT MONTH)
Igor **KHARITONENKO**		June 12, 2001
RESIDENCE: 19 Dobson Street, Thornleigh, New South Wales 2120, Australia		CITIZENSHIP: Australian Citizen
POST OFFICE ADDRESS: Same as above	Anx	